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IMPROVING U.S. NAVY SHIPBOARD HABITABILITY: EFFECTS OF LIGHT AND TEMPERATURE IN BERTHING COMPARTMENTS

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IMPROVING U.S. NAVY SHIPBOARD HABITABILITY: EFFECTS OF LIGHT AND TEMPERATURE IN BERTHING COMPARTMENTS

by

Megan C. Mittleider

March 2020

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13. ABSTRACT (maximum 200 words)

The safe and effective operation of U.S. Navy ships is dependent on Sailors who must stand an alert and responsive watch. When Sailors become fatigued, mishaps and accidents with grave consequences can occur. Habitability factors onboard Navy ships have a direct impact on a Sailor's ability to obtain adequate sleep. Specifically, light and temperature within the berthing compartment can have an effect on a Sailor's sleep.

This study investigates the rack curtain's effect on light and temperature in the enlisted berthing compartments onboard an underway Navy ship. Two different rack curtains were examined in the study: the standard-issue Navy rack curtain, and an enhanced commercial-off-the-shelf variant. The participants with a standard variant rack curtain received, on average, 5.76 hours of sleep daily. Those with the enhanced variant rack curtain received 5.97 hours of sleep daily. Light and temperature were monitored within each individual participant's rack. The study found that the enhanced variant rack curtain improved temperature regulation within the rack. Less light was able to permeate the enhanced variant rack curtain than the standard variant rack curtain. Selecting a rack curtain that enhances Sailors' ability to sleep is a cost-effective and easily implemented means of improving habitability onboard U.S. Navy ships.

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IMPROVING U.S. NAVY SHIPBOARD HABITABILITY: EFFECTS OF LIGHT AND TEMPERATURE IN BERTHING COMPARTMENTS

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The safe and effective operation of U.S. Navy ships is dependent on Sailors who must stand an alert and responsive watch. When Sailors become fatigued, mishaps and accidents with grave consequences can occur. Habitability factors onboard Navy ships have a direct impact on a Sailor's ability to obtain adequate sleep. Specifically, light and temperature within the berthing compartment can have an effect on a Sailor's sleep.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	analysis of variance
CNSP SURFOR	Commander Naval Surface Force, U.S. Pacific Fleet
COTS	commercial off-the-shelf
CSV	comma-separated value
DDG	guided missile destroyer
ESS	Epworth Sleepiness Scale
HFE	human factors engineering
HSI	human systems integration
IRB	Institution Review Board
ISI	Insomnia Severity Index
MEMS	Micro Electro-Mechanical System
NAVSEA	Naval Sea Systems Command
NMP	Navy Modernization Program
NPS	Naval Postgraduate School
NREM	non-rapid eye movement
NTSB	National Traffic Safety Board
PAB	Performance Assessment Battery
PANAS	Positive Affect and Negative Affect Scales
POMS	Profile of Mood States
PRM	probed recall memory
PSQI	Pittsburgh Sleep Quality Index
PVT	psychomotor vigilance test
REM	rapid eye movement

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EXECUTIVE SUMMARY

Unique among the armed services, the notion of the Sailor standing the watch is evocative of the ethos of the Navy. That Sailor on watch must be alert, attentive, and responsive in order to keep their ship and shipmates safe. The deadly collisions of 2017 involving the USS JOHN S. McCAIN (DDG 56) and USS FITZGERALD (DDG 62) were a painful indication that something was amiss within the fleet. Both incidents were investigated, and in the National Transportation Safety Board's 2019 report on the USS JOHN S. McCAIN, they specifically point out that "Relying on fatigued crewmembers to accomplish normal, daily tasking introduces unnecessary risk" (p. 35).

The deleterious effects of fatigue are well documented. In 1997, Dinges et al. limited subjects' sleep to five hours per day for a week, and then ran a number of tests to determine the impact on the subjects' performance. The subjects' reaction times during psychomotor vigilance testing significantly worsened as the subjects became more sleep deprived. That same study found that cognitive performance was also negatively affected by fatigue. As fatigue increases, a person's mood worsens and they experience more stress. Similar findings were shown in a 2005 study by Zohar et al., which determined the connection between sleep duration and emotional reactions. Subjects who were sleep deprived experienced more intense negative emotions. When Minkel et al. (2012) gave sleep deprived subjects stress-inducing tasks in the form of mental arithmetic problems, they found that the fatigued subjects became highly stressed by what was designated as a low-stressor task. Non-fatigued subjects were able to complete the same low-stressor task with minimal stress.

Sleep deprivation and its accompanying fatigue can be avoided by getting an adequate amount of sleep, which the American Academy of Sleep Medicine and the Sleep Research Society (Watson et al., 2015) stipulates as seven to nine hours of sleep. Operational requirements on U.S. Navy ships can cause Sailors to receive less sleep; however, it would be remiss not to investigate the habitability conditions onboard ships to assess whether these conditions are optimal for sleep. Per the Navy's instruction for the Shipboard Habitability Program (2016), "[h]abitability is that military characteristic of

U.S. Navy ships directed toward satisfying personnel needs which are dependent upon physical environment” (p. 1–1). Habitability factors include light and temperature. One overlooked facet of habitability is the rack curtain. The standard-issue Navy rack curtain is only supposed to provide privacy, yet a market exists among Sailors for purchasing an enhanced commercial-off-the-shelf variant rack curtain, which is often customizable in a number of different ways.

This study provides data on sleep of crew members from a Navy ship utilizing circadian-based watchbills and provides insight into potential methods for improving shipboard habitability. The objective is to determine if there is a measurable difference between the two rack curtain variants onboard the ship in terms of sleep, temperature fluctuations, and light penetration within the rack. Studies by Libert et al. (1991) and Okamoto-Mizuno, Tsuzuki, Mizuno, and Iwaki (2005) showed that subjects’ sleep quality suffered in higher temperatures. Research by Badia et al. (1991) demonstrated that exposure to light increased subjects’ alertness and interrupted their sleep. Figueiro and Rea’s study in 2012 showed that even a minimal amount of light shined on a subject’s closed eyes was sufficient to disrupt sleep.

Participants for this current study were recruited from the crew of the USS MOMSEN (DDG 92), which was conducting high-tempo operations at sea for the duration of the study. The enlisted participants were grouped according to their rack curtain variant: the standard-issue Navy rack curtain, or the enhanced commercial-off-the-shelf rack curtain. Light and temperature data were collected internal and external to each participant’s rack to gauge the effectiveness of the rack curtain in preventing light exposure and controlling temperature. Surveys and sleep watches were also given to participants to determine their sleep patterns, fatigue levels and mood.

The 71 participants in this study received 5.78 (±0.96) hours of sleep daily on average. Officers averaged 5.50 (±1.09) hours of sleep daily, and Enlisted averaged 5.84 (±0.93) hours of sleep daily. Among enlisted participants with the standard variant rack curtain, average daily sleep was 5.76 (±0.90) hours. Enlisted participants with the enhanced variant rack curtain received an average of 5.97 (±0.80) hours of sleep daily or ~13 minutes more sleep than their counterparts with the standard variant.

In surveys, 60% of participants responded that background lighting interfered with their sleep and 67% responded that temperature (either too hot or too cold) interfered with their sleep. The study found that temperatures within enhanced variant racks were generally cooler than standard variant racks. During sleep, temperatures internal and external to a participant's rack fluctuates over a range. Participants with enhanced variant rack curtains experienced similar range fluctuations between internal and external temperatures. The enhanced variant rack curtain reduced light intensity within the rack by 46.7%, as opposed to 41.1% with the standard variant rack curtain. However, analysis showed that the amount of light reduction was not greatly different between the two rack curtain variants.

In conclusion, the enhanced rack curtain can improve habitability within the berthing compartments, not only through its light and temperature properties, but also through the utility of customizations such as pockets or fasteners that are available. This feature can provide Sailors with increased storage and convenience, improving morale and creating tidier spaces. It is time for the Navy rack curtain to go beyond the initial design criteria of merely providing privacy. This study recommends that the Navy further investigate the usage of enhanced rack curtains as a cost-effective and easily implemented means of improving habitability and sleep onboard ships.

Further investigation may include a larger study where an entire ship is outfitted with enhanced variant rack curtains. Data would be collected prior to and after outfitting the enhanced variant rack curtains to determine if there is a difference in the crew's sleep, mood, and performance. A study can also be conducted to compare enhanced variant rack curtains from different manufacturers, with a focus on material construction and cost analysis. Additionally, a survey can be conducted throughout the fleet to determine the current prevalence of enhanced rack curtains on ships.

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I. INTRODUCTION

The most dangerous phrase in the language is,
"We've always done it this way."

—RADM Grace Hopper

A. BACKGROUND

In response to the 2018 National Defense Strategy, the Chief of Naval Operations promulgated Design 2.0, which provides operational guidance for maintaining the United States' superiority in sea power amid an increasingly advanced and dangerous field of global competitors. Design 2.0 has made it clear that today's Sailor can expect to face increasingly complex challenges and more tasking. Sailors will be given the training and tools to accomplish these tasks, but focus must also be placed on changing previously common practices for the better (United States, 2018).

Too little sleep has adverse effects on decision making abilities, reaction times, memory, and well-being (Dinges et al., 1997). It has been shown that Sailors while underway receive less sleep than recommended, and it has become commonplace for Sailors and commands to accept this as a standard practice (Skornyakov et al., 2017). In recognition of sleep's importance to operational readiness and warfighting ability, the Navy has directed the adoption of circadian-based watchbills by all surface ships (Department of the Navy [DoN], 2017). The circadian-based watchbill leverages the body's endogenous biological rhythm to ensure that Sailors' sleep is both maximized and timed for optimal benefit (Ehrlich, 2016). However, the benefits of an optimized watchbill are undermined if environmental conditions in shipboard berthing compartments are not conducive to sleep.

These environmental conditions are a part of habitability. Habitability consists of factors in the physical environment that make a space inhabitable. These factors form an environment where Sailors can live and work efficiently. The goal of habitability is to sustain maximum personnel effectiveness and morale on Navy ships (NAVSEA, 2016).

Every Navy ship is constructed to meet a habitability standard, but changes to habitability standards will be considered if there is evidence to suggest that conditions onboard U.S. Navy ships can be altered to provide better living and working conditions for Sailors. Sleep is an integral part of sustaining maximum personnel effectiveness and morale, and studies have identified light and temperature as factors that affect sleep (Aschoff, 1965).

B. SCOPE

This thesis focuses on the effect of the rack curtain on habitability. While rack curtains are originally intended only to provide privacy (NAVSEA, 2016), data will be analyzed to determine if the rack curtain affects light levels and temperature within the rack, thereby affecting sleep. By measuring the quality and quantity of a Sailor's sleep and comparing that with physical conditions within the rack, it can be determined if the rack curtain assists in creating an environment conducive to sleep.

By focusing on rack curtains, this thesis provides a data-driven recommendation to the Commander of Pacific Naval Surface Forces (CNSP SURFOR) on an affordable and easily implemented improvement to shipboard habitability. Until this point, research has not been conducted on the role of rack curtains in aiding sleep, or the effect of rack curtains on light or temperature. This study explores a possible methodology for collecting data concerning rack curtains, light, and temperature. It also provides data for the body of work of concerning sleep and habitability and may serve as a proof of concept for further work in this field. Recommendations will be made for future research and follow-on studies. The goal is to provide improvements to Sailors' sleep quantity and quality, improve operational readiness, and ensure Sailors are more alert, motivated, and ready to respond to the situation at hand.

C. OVERVIEW

The study took place over the course of twelve days onboard USS MOMSEN (DDG 92), an operational Type 2 Arleigh Burke Class destroyer based out of Everett, WA. This ship was chosen because it utilized two variants of rack curtains in the enlisted berthing compartments and would be engaged in high tempo operations at sea for the duration of

the study. The two rack curtain variants differed in quality, construction, and material. Sailors who volunteered to participate in the study were issued a wrist activity monitor (Actiwatch). They completed a pre-study questionnaire and Profile of Mood States (POMS) survey. Their berthing compartment, rack location, and curtain variant were noted. A temperature and light monitoring instrument (HOBO) was placed inside the participant's rack with another placed on the exterior of the rack outside of the rack curtain. Participants were instructed to complete an activity log each day during the study.

At the conclusion of the study, the Actiwatches and activity logs were collected. Each participant completed a post-study questionnaire and another POMS survey. The HOBOs were collected from the berthing compartments and their data, along with the data from the Actiwatches, were downloaded. The data from the Actiwatches showed when the participant was active or asleep and the light levels to which the wrist-worn device was exposed at the time. The actigraphy data were compared with the participant's activity log to create an accurate schedule of when they were awake and asleep. The data from the HOBOs were analyzed for the period of time when the participant was asleep to determine the effect of light and temperature on sleep duration and quality. The pre- and post- study questionnaires and surveys were analyzed and compared.

These datasets were then analyzed to assess individuals' sleep patterns and determine what effect, if any, the rack curtain variant had on sleep quality and quantity. A comparison of light and temperature internal and external to the rack was analyzed, taking into account various habitability factors within the individual berthing compartments (e.g., proximity to vents, light sources).

D. OBJECTIVES

The study conducted for this thesis provides data on sleep from the crew members on a Navy ship utilizing circadian-based watchbills and provides insight into potential methods for improving shipboard habitability. The objective is to determine if there is a measurable difference between the two rack curtain variants onboard the ship in terms of temperature fluctuations and light penetration within the rack. Based on the findings, recommendations are made on rack curtain variants and future research.

In Chapter II, previous research and scientific literature on the subject are presented to lay the framework for this study. Chapter III details the study in greater depth, explains the methodology, and introduces the analytical procedures. Chapter IV presents and analyzes the study data. Chapter V discusses the findings from the previous chapter and offers conclusions drawn from the study. Chapter VI provides recommendations and further work.

II. LITERATURE REVIEW

A. SLEEP BACKGROUND

Sleep is crucial to human performance. It is a complex neurophysiological function that, until recently, has been poorly understood yet highly sought after. From an observational perspective, sleep occurs when a person is not fully conscious and is characterized by a recumbent pose, flaccidity or atonality of muscles, and nonresponsiveness. Biologically, sleep is dependent on many factors and therefore susceptible to minute changes that can result in sleep disturbance (Altevogt & Colten, 2006, Chapter 2, p. 38–39). Sleep has a restorative effect; the onset of fatigue is a cue for sleep, and upon waking the mind and body should feel refreshed. When the amount and quality of sleep is inadequate, the restorative effect is diminished and human performance suffers (Pilcher & Huffcutt, 1996). According to a consensus conference panel consisting of experts from the American Academy of Sleep Medicine and the Sleep Research Society (Watson et al., 2015), a healthy adult requires seven to nine hours of sleep. In the United States general population aged 16 years and older, the average sleep duration is 6.9 hours (Hou, Liu, & Liu, 2018). For a Sailor deployed on an operational warship, that average has been reported to drop to 5.58 hours (Miller, Matsangas, & Kenney, 2012).

1. The Biology of Sleep

Sleep is not merely the closing of one's eyes and the cessation of consciousness. It is controlled by an innate process and results in complex neurological, biological, and chemical changes within the body. The culmination of all these activities is a good night's sleep. Humans are governed by the circadian rhythm which sets an approximately 24-hour cycle by which the body's biological processes, including sleep, function (Figueiro, 2013). The circadian rhythm originates from the suprachiasmatic nucleus of the anterior hypothalamus (Altevogt & Chapman, 2006, Chapter 2, p. 42–43). Without external stimulation, the circadian rhythm will cause the body's core temperature and hormone levels to fluctuate throughout the day (Aschoff, 1965). One of these hormones, melatonin, is closely associated with sleep. Increased secretion of melatonin occurs at night and

initiates the onset of sleep. Melatonin continues to be secreted throughout the night and aids the body in remaining asleep. As morning approaches, the circadian rhythm will cause melatonin production to decrease and cortisol, a stimulating hormone, will begin to be produced in its place (Badia et al., 1991). The dark of night and the light of morning are the principal external stimuli that set the periodicity of the circadian rhythm. If these light stimuli are changed, the circadian rhythm will adjust itself to the new periodicity in a process known as entrainment (Rusak & Zucker, 1979).

In order for sleep to have the appropriate restorative effect, both non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep must occur. NREM sleep occurs first during the ~90-minute sleep cycle and consists of four stages starting at stage 1 (awake) and progresses through stage 4 (deepest sleep) (Matthews, 2000). REM sleep occurs towards the end of each sleep cycle and is marked by increased brain activity, such as dreaming. The cycles repeat and as the sleep period progresses, the amount of NREM sleep lessens while REM sleep increases, as shown in Figure 1. REM sleep has been shown to be necessary for consolidation of memories and perceptual learning (Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994).

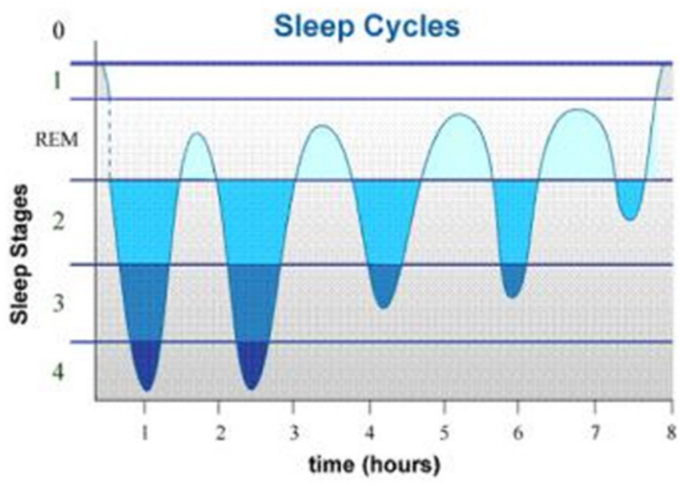

Figure 1. Sleep stages over an 8-hour sleep period. Source: Miller et al. (2007).

2. Sleep and Temperature

Core body temperature fluctuates throughout day in synchronization with the circadian rhythm. When the circadian rhythm triggers sleep with the production of melatonin, core body temperature will also drop. According to a study by Czeisler et al. (1980) the drop in core body temperature correlates to the shaded sleep periods, as illustrated in Figure 2. As the time for waking approaches, core body temperature begins to rise. The highest core body temperatures are seen during periods of maximum alertness.

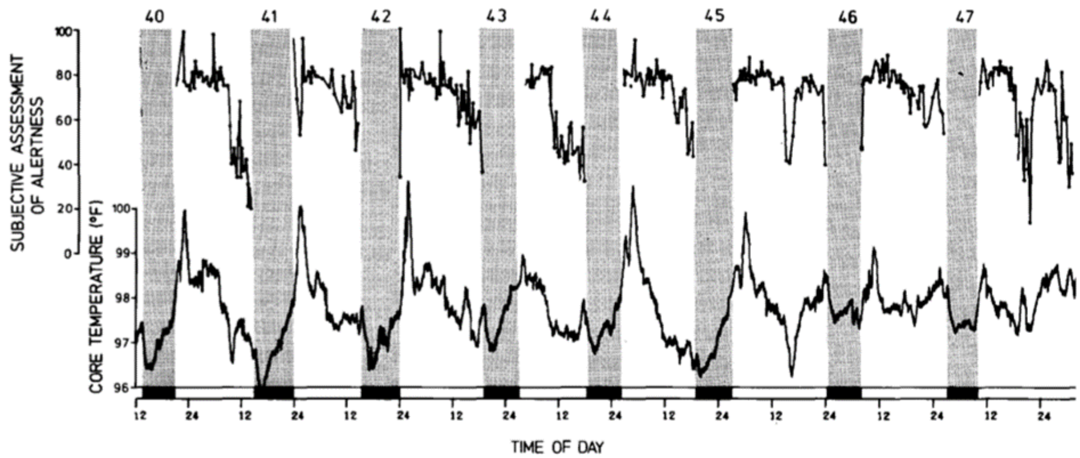

Figure 2. Fluctuation of core body temperature during periods of sleep and wakefulness. Source: Czeisler, Zimmerman, Ronda, Moore-Ede, and Weitzman (1980).

As anyone who has tried to sleep during a hot summer night knows, high temperatures can disrupt sleep. This anecdote was corroborated in a study by Libert et al. (1991), where study participants slept in varying combinations of temperature (20°C or 35°C) and noise. That study found that higher temperature had a greater negative impact than noise on participants' sleep quality. Similarly, research by Okamoto-Mizuno, Tsuzuki, Mizuno, and Iwaki (2005) found that as temperature was increased throughout the night from 26°C to 32°C, the participants' core body temperatures would correspondingly also increase and a higher number of sleep interruptions would occur.

In a study by Wyatt et al. (1999), six subjects had their circadian rhythms entrained to a 20-hour cycle as opposed to the standard 24-hour cycle. Even with this forced desynchronization of the circadian rhythm, the 24-hour temporal relationship of body temperature and sleep was observed: lower temperatures signaled the onset of sleep, and higher temperatures indicated sleep disruptions. For good quality sleep to occur, core body temperature must be lower.

3. Sleep and Light

Light and darkness are important factors that can affect circadian timing and therefore sleep. Research by Badia et al. (1991) indicates that light has an immediate and powerful effect on alertness. Subjects were exposed to light of varying intensity during both daytime and nighttime hours. Following this exposure to light, subjects completed a performance assessment battery and wakefulness test to gauge their alertness. Bright light administered during nighttime hours had the greatest effect on increasing alertness. The study also found that bright light administered during nighttime hours caused body temperatures to increase when normally they would be lower. Light, while able to induce alertness, also interrupts sleep.

Light need not be considered bright in order to disrupt sleep and induce alertness. When eyelids are shut the amount of light received by the retina is decreased by about two orders of magnitude. Research by Figueiro and Rea (2012) suggests that even a small amount of retinal light exposure at night can suppress melatonin production. For their research, participants wore light-emitting masks while asleep. Over three intervals during the night, the light-emitting masks shined light of approximately 100 lumens on the individual’s closed eyes. Blood samples were collected at regular intervals to measure the amount of melatonin in the participant’s bloodstream. As demonstrated in Figure 3, melatonin concentrations decreased immediately after retinal light exposure and continued to decrease up to an hour later. Decreased melatonin production alters the structure of sleep and can result in sleep disruptions and poorer sleep quality.

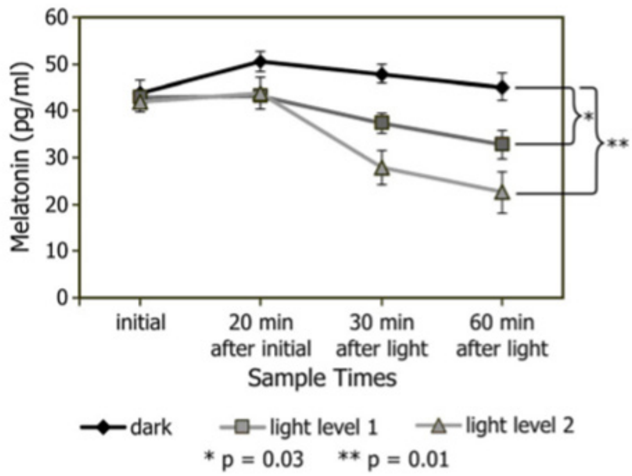

Figure 3. Melatonin concentration following exposure to light.
Source: Figueiro and Rea (2012).

Exposure to light, however little, has an impact on the body's circadian rhythm and ability to sleep. Boivin, Duffy, Kronauer, and Czeisler (1996) exposed subjects to four different light intensities prior to sleep. The subjects' core body temperatures were monitored and used to determine the extent of circadian entrainment. Using this information, the researchers created a dose-response curve showing the entrainment of the circadian rhythm in relation to light intensity (Figure 4). This dose-response curve shows that the circadian rhythm is sensitive to even very low doses of light, where 180 lux corresponds to a normal indoor room light. Inadvertent exposure to low levels of light can cause a phase shift of the circadian rhythm, and if that phase shift results in misalignment of the individual's circadian sleep period and actual sleep period, sleep quality is worsened (Flynn-Evans, Barger, Kubey, Sullivan, & Czeisler, 2016).

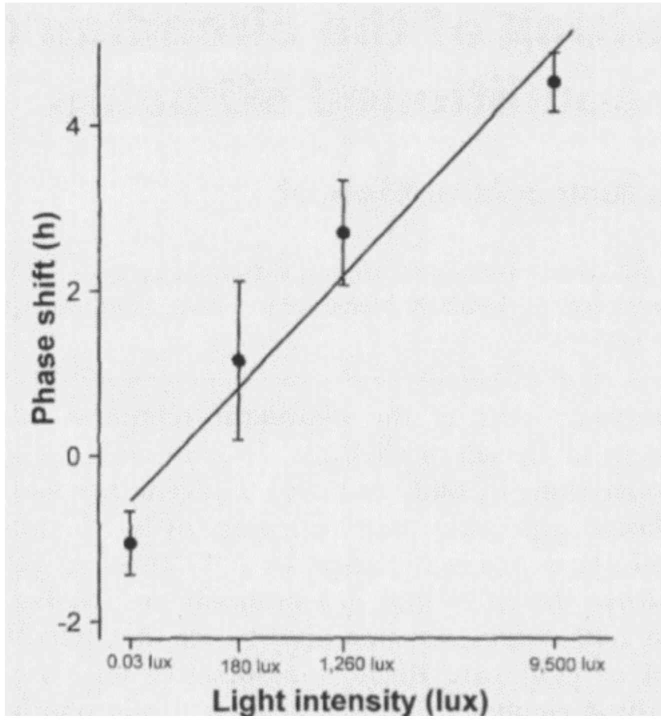

Figure 4. Dose-response curve showing photic resetting of circadian rhythm. Source: Boivin, Duffy, Kronauer, and Czeisler (1996).

The wavelength of light can also have an impact on sleep. Light can be characterized by its correlated color temperature, which is measured in kelvins (K). Compact fluorescent lamps typically emit light at 6500K, which is considered blue-shift, or “cold light.” The effect of blue light and sleep was explored by Chellappa et al. (2011) whose study consisted of exposing subjects to light of varying wavelengths (2500K, 3000K, and 6500K) for two hours in the evening prior to sleep. Subjective surveys, salivary melatonin collection, and psychomotor vigilance tests (PVT) were used to evaluate the subjects’ sleepiness and alertness. Their study found that blue light of 6500K suppressed melatonin and led to increased alertness and faster response times.

4. Sleep and Human Performance

Inadequate sleep is known to degrade human performance. It is widely accepted that humans need, on average, 8 hours of sleep daily. When this requirement is not met, a person’s physical performance, mental performance, and mood suffer. Unfortunately, this can have serious consequences in situations where human performance needs to be at its

best. The 2017 collisions of the USS JOHN S. McCAIN (DDG 56) and USS FITZGERALD (DDG 62), which resulted in the loss of 17 lives, had numerous causes. Investigations by the Navy and the National Transportation Safety Board (NTSB) identified a common thread between the collisions: watchstander fatigue due to lack of sleep. The National Transportation Safety Board 2019 report on the USS JOHN S. MCCAIN collision stated the following: "Relying on fatigued crewmembers to accomplish normal, daily tasking introduces unnecessary risk" (p. 35).

Sleep deprivation has been shown to result in reduced performance in various tasks. Participants in a study by Dinges et al. (1997) had their sleep restricted to approximately five hours daily for one week and were given a number of neurobehavioral tests. The psychomotor vigilance test (PVT) measures the participant's reaction time and the probed recall memory (PRM) test measures memory performance. The study found that slower reaction times and more lapses, or failures to react, during the PVT were a good predictor of sleep deprivation. As seen in Figure 5, the number of PVT lapses increased as the days of sleep deprivation went on. Similarly, poor performance on the PRM test also indicated sleep deprivation. Participants were also administered Profile of Mood States (POMS) surveys which showed that their behavioral mood was more negative with sleep deprivation. By restricting participants' sleep duration to only 66% of normal, measurably worse human performance, both physical and cognitive, can be observed.

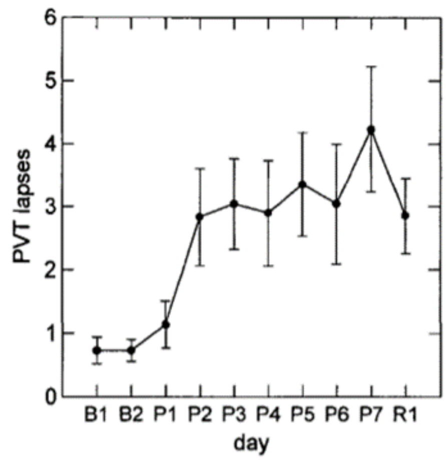

Figure 5. Number of PVT lapses over the course of seven days of sleep deprivation. Source: Dinges et al. (1997).

Lack of sleep causes disturbances in a person’s mood; irritability is commonly associated with sleep deprivation. In a study by Zohar et al. (2005), regression analysis was used to determine the connection between sleep duration and emotional reactions. Sleep was recorded using actigraphy for 78 medical residents during the course of the study. Each day, for three consecutive days, the residents received three random phone calls reminding them to fill out their study questionnaires. The questionnaires, consisting of Positive Affect and Negative Affect Scales (PANAS) and POMS surveys, were used to rate their mood and fatigue. The study found that residents who were sleep deprived experienced more intense negative emotions and fatigue.

According to Minkel et al. (2012), sleep deprivation also effects a person’s perception of stress. In their study, sleep deprived participants were given stress-inducing tasks in the form of mental arithmetic problems. The stress level of these problems was classified as low or high, depending on the problem’s difficulty. Stress level was measured via self-reporting and POMS surveys. Subjective stress levels for the high stressor tasks were similar between the sleep deprived and non-sleep deprived participants. However, for the low-stressor tasks, sleep deprived participants reported experiencing much higher levels of subjective stress than the non-sleep deprived participants. What should have been an easy, mundane task became a highly stressful task for those who were sleep deprived.

B. HABITABILITY BACKGROUND

If a physical space is capable of being lived in, it is considered habitable. The extent to which it can be lived in is called habitability and is dependent on many factors. The habitability of a muddy cave differs greatly from a hotel suite and yet both spaces are capable of being inhabited. Habitability is an important consideration in the design of any living space. Aside from making the space livable, habitability can also focus on improving some other aspect of the space. Habitability on Navy vessels is a concern; they are warships but they must also house upwards of 6,000 people within extremely limited space.

1. Habitability on U.S. Navy Ships

The design of all Navy ships is governed by specific criteria. Those criteria that pertain to shipboard facilities and spaces occupied by Sailors are known, collectively, as habitability. As stated in the Navy's instruction for the Shipboard Habitability Program (NAVSEA, 2016), "[h]abitability is that military characteristic of U.S. Navy ships directed toward satisfying personnel needs which are dependent upon physical environment" (p. 1–1). Changes to shipboard habitability are generally accomplished via the Navy Modernization Program (NMP) with greatest priority placed on changes that improve the established criteria for climate control in berthing, messing, and sanitary spaces (DoN, 2012). Climate control includes, but is not limited to, temperature, lighting, humidity, noise, and ventilation.

Habitability has its roots in human factors engineering (HFE) and is one of the major domains in human systems integration (HSI). HFE looks at the interaction between personnel and their surroundings. Surroundings are designed to take into account the personnel's capabilities and any requirements or constraints. According to Stein et al. (1983), every element onboard a ship should be planned, designed, and implemented to meet the needs of the Sailor as well as those of the system or program. Per the Navy, HFE, and by extension habitability, ensures the readiness of personnel which in turns ensures the readiness of the ship. To some extent, HSI has since replaced HFE within the Navy. HSI is an integrated systems engineering process and program management effort with the same overall goal as HFE: personnel and ship readiness (Department of Defense [DOD], 2011).

2. Habitability and Sleep

The provisions for habitability onboard U.S. Navy ships are outlined in a NAVSEA technical publication (2016). These provisions cover everything from the paint color on bulkheads to the arrangement of vending machine areas. The Shipboard Habitability Program provides guidelines for climate control in occupied spaces. These guidelines are chosen with work in mind. Habitability specific to the berthing compartments focuses on physical layout and only considers minimizing noise to sleepers (NAVSEA, 2016).

Habitability on U.S. Navy ships and its role in sleep was explored during a study by Archibald (2005). That study measured noise, temperature, humidity, motion, and light in the berthing compartments onboard the USS SWIFT (HSV 2), a high-speed vessel that was conducting a high-tempo operation at sea. The temperature measurements from this study were recorded using a single data logger placed in each berthing compartment. The light measurements were recorded in two of the berthing compartments by a single device. Thus, the light and temperature data from this study can be considered general area measurements. The study found that light had a significant effect on sleep efficiency, with a 4% decrease in sleep efficiency for every increase in light value (lux).

Another habitability and sleep study looked at the impact of exposure to blue light. Previous studies have attributed blue light exposure to reduced melatonin secretion and increased alertness (Chellappa et al., 2011). Ryan, Matsangas, Anglemyer, and Shattuck (2017) explored the possibility of improving sleep in a military population by limiting exposure to blue light, such as that emitted by most compact fluorescent lights, through the use of glasses with tinted lenses that blocked blue light. The study took place over two weeks; the first week was a control week with no intervention, the second week was the treatment week when participants wore the blue light blocking glasses for two hours prior to bedtime. Sleep actigraphy was collected over the duration of the study, and subjective survey data was collected at the beginning of the control week, the beginning of the treatment week, and the end of the study. They found that blocking blue light prior to bedtime was beneficial and resulted in reduced daytime sleepiness and improvement in mood. A total of 71 crew members volunteered; 14 were officers and 57 were enlisted personnel with 58 males and 13 females. 58 usable sets of sleep data were obtained from

71 participants. However, for comparison of rack curtain variants, only the junior enlisted participants' (E6 and below) data were used because the enlisted berthing spaces were the primary areas of interest.

The participants, both officer and enlisted, came from every department onboard the ship, as seen in Figure 6. The enlisted participants came from 18 different ratings and varied in rank from E2 to E7. A complete breakdown of participants by rank is seen in Figure 7. The USS MOMSEN used a total of five berthing spaces for junior enlisted personnel. The junior enlisted participants for this study came from all five of those berthing spaces.

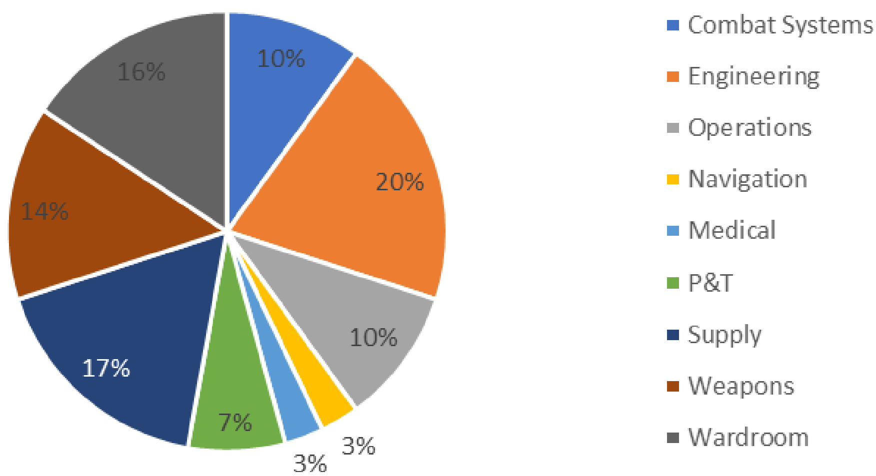

Figure 6. Breakdown of participants by department

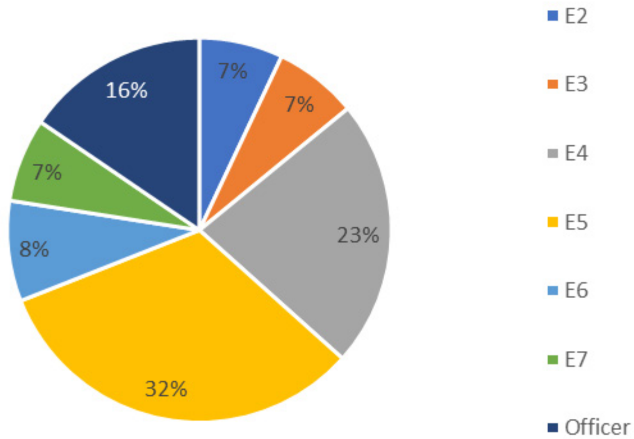

Figure 7. Breakdown of participants by rank

C. INSTRUMENTATION

1. Sleep and Actigraphy

A medical-grade wrist-worn activity monitor (Actiwatch, Philips Respironics) was used to collect sleep study data from participants. It is worn on either wrist and houses a Micro Electro-Mechanical System (MEMS) accelerometer and a light sensor. For this study, the Actiwatch recorded data at 1-minute epochs. The input from the accelerometer was saved in onboard memory and then uploaded to the Actiware companion computer program. Using a proprietary algorithm, the program determines when an individual was active or asleep. The raw data from the Actiwatch was output to a comma-separated value (CSV) file for further analysis. An actigram can also be created to give a visual representation of the Actiwatch's results. Participants were issued an Actiwatch at the beginning of the study and instructed in its use. Participants were advised to wear the Actiwatch as frequently as possible, but to remove it during showering, dangerous evolutions, or if any irritation occurred.

2. Light and Temperature

Light and temperature data were collected both internal and external to a participant's rack using light and temperature monitoring devices (HOBO, Onset; EM300, Extech Instruments). The HOBO is battery powered and consists of a circuit board and

sensors housed within a transparent, water-proof plastic case. For this study, the HOBO recorded data at 5-minute epochs. The HOBO records temperature in degrees Fahrenheit and light intensity in lumens. One HOBO was placed outside of the rack and is denoted as the external HOBO while another HOBO was placed within the rack and is denoted as the internal HOBO. The internal HOBO was affixed inside the participant's rack at approximate eye level. General area temperatures were monitored within each berthing compartment using the EM300 environmental meter. Additionally, general area light measurements were collected in each berthing compartment using a spectrophotometer (CL-500A Illuminance Spectrophotometer, Konica Minolta).

D. DATA COLLECTION

1. Pre-study Assessments

Crew members, upon consenting to participate in the study, were given a pre-study questionnaire to establish demographic information and obtain an individual assessment of that participant's sleep habits. The pre-study questionnaire, provided in Appendix B, included questions about the participant's caffeine and nicotine usage, medications and previous sleep diagnoses, and frequency of physical exercise. The participant was assigned a non-personally identifiable case number for tracking purposes. Participants self-reported their current watch schedule and any previous schedules to which they had been subjected. A standardized POMS survey was completed by each participant to assess their mood state.

2. Berthing Data

During a previous trip to the USS MOMSEN, the layout of every enlisted berthing space was mapped with the assistance of Naval Postgraduate School (NPS) student researchers. The purpose of these layouts, such as the one shown in Figure 8, was to provide the researchers with an accurate representation of every individual rack within the berthing space, as well as the orientation of various factors that affect habitability. These layouts included lighting, ventilation ducts, loudspeakers, phones, and any other element that might affect an individual's ability to sleep. The berthing space and exact rack location of every enlisted participant was recorded during the pre-study assessment. Because this study focused on light and temperature, the proximity of a participant's rack to a light source or

ventilation duct could affect results. General area light levels were also recorded using the spectrophotometer. This information included the location of white (day) and red (night) lights.

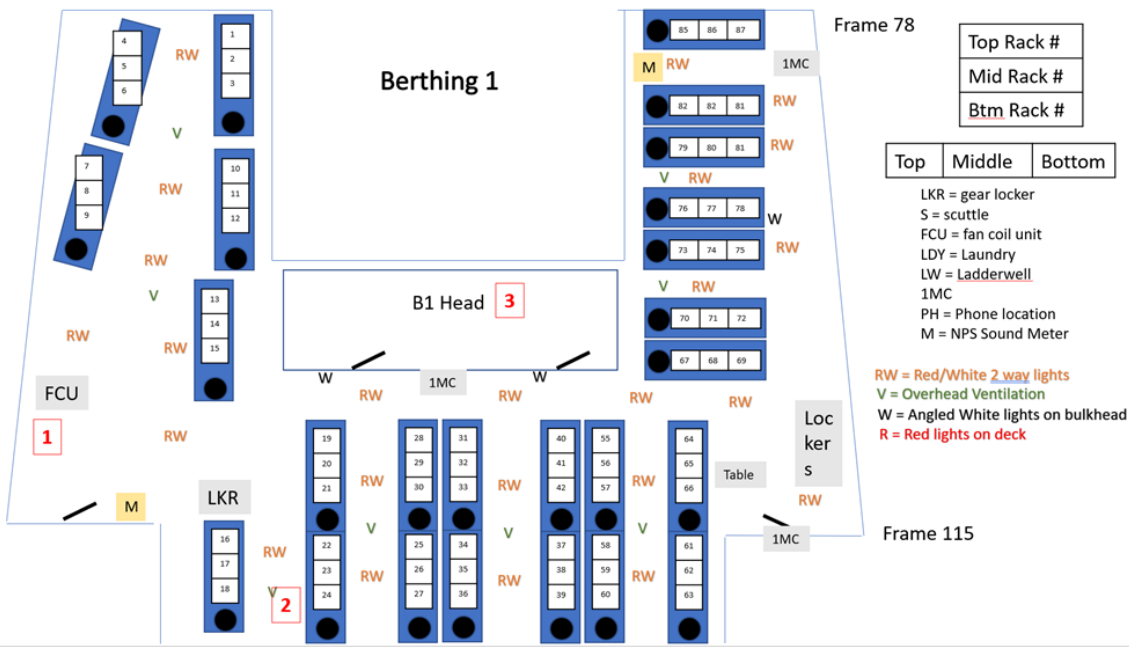

Figure 8. Detailed layout of an enlisted berthing compartment

The enlisted participants came from all five enlisted berthing compartments onboard the ship, as shown in Table 1. On average, 22% of a given berthing compartment participated in the study. Because the participants were all volunteers and had been underway for quite some time, their individual rack location and curtain variant were not under the control of the research team and are random rather than being assigned.

Table 1. Distribution of participation by compartment

Berthing #	Compartment	Total Capacity	# of Study Participants	% Compartment Participation
1	2-78-91-L	87	14	16.1%
2	3-97-02-L	48	11	22.9%
3	2-300-01-L	90	18	20%
4	3-300-1-L	27	8	29.6%
5	3-310-2-L	21	5	23.8%

The racks in enlisted berthing are stacked and consist of a bottom, middle, and top rack. The features and layout of the racks are shown in the schematic of Figure 9. The overhead of the top rack is open to the compartment. The middle and bottom racks have approximately 20 inches of clearance. The internal dimension of the rack is 78 inches long and 27 inches in width. The opening into each rack can vary based on the configuration of lockers and bulkheads within the berthing space.

The rack curtain, which comes in two panels, is affixed via hooks to a rail running the length of the rack opening. The Navy-issued standard rack curtain is manufactured under government contract. It is made from a single layer of polyester-cotton blue fabric. The enhanced COTS rack curtain is made from blue polyester fabric backed with thin, white plastic and manufactured to have pockets on the internal side of the curtain. When purchasing the COTS rack curtain, measurements are specified for the manufacturer to accommodate various rack opening dimensions. Of the enlisted participants, 35 used the standard variant Navy-issued rack curtain and 19 used the enhanced variant COTS curtain. There were no changes to rack curtains or berthing arrangements over the course of the study.

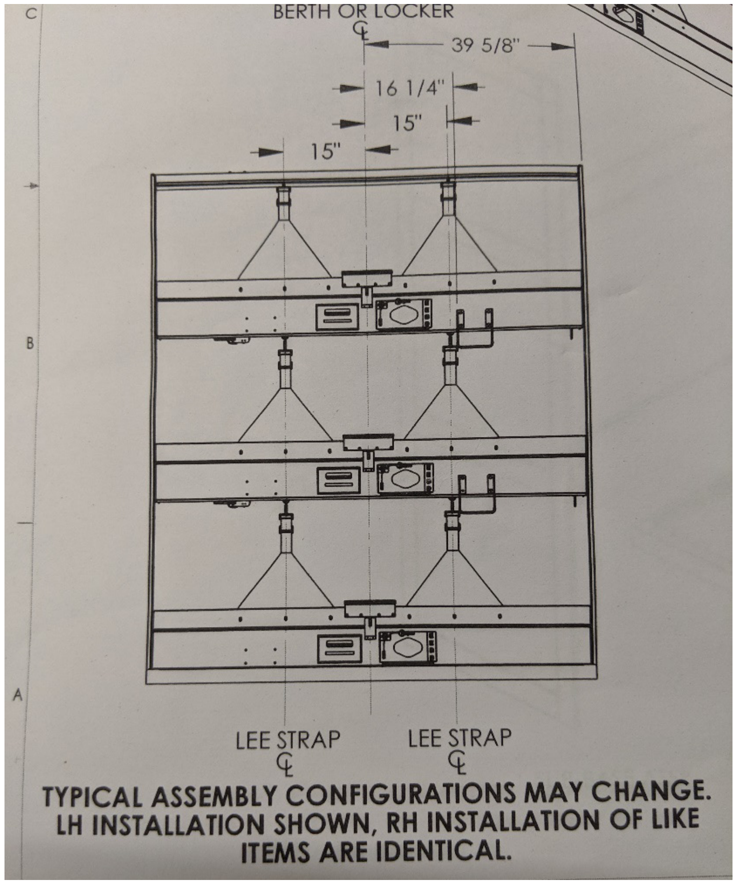

Figure 9. Schematic showing layout of three-person stacked rack. Source: Naval Sea Systems Command (2005).

3. Sleep Data

The main source of sleep data, the participants' Actiwatches, was output as both a CSV file and an actigram. Each participant's actigram was assessed and scrubbed to ensure that activity and sleep were accurately represented. This scoring process was aided by comparison with the participant's Activity Log. Each day in the Activity Log was broken up into 15-minute increments. Participants were instructed to annotate their periods of sleep and activity on a daily basis within the Activity Log. Using their self-reported sleep and activity data, the raw actigrams were scrubbed to include correct periods for activity and sleep.

The sleep times presented herein are described as the amount of time the participant is actually asleep. Time in bed is a separate value that can vary greatly from the actual

amount of sleep that the participant received, due to differences in time it took for a participant to fall asleep and the number of awakenings they experienced during their sleep period.

4. Light and Temperature Data

The HOBOs recorded time, temperature, and light levels at five-minute epochs. This information was then stored in the HOBO onboard memory bank. Upon collection of the HOBO, the datafile is uploaded to the proprietary HOBOsoft computer program and saved as a CSV file. The data collected consisted of a time stamp, light intensity in lumens, and temperature in Fahrenheit.

Light and temperature data were collected from every participant's rack using a pair of HOBOs set up inside and outside of the rack. One end of a rack has an installed overhead reading light. At the opposite end is a small, switch-operated ventilation fan. The internal HOBO, denoted by B in Figure 10, was positioned within the rack at a location corresponding to the position of the occupant's eyes. The external HOBO, denoted by A in Figure 10, was positioned immediately exterior to the rack.

Figure 10. Demonstration of position of internal and external HOBOs on rack

When a rack is occupied by the participant, the rack curtain is drawn shut and the internal HOBO only registers light and temperature within the confines of the rack. Rather

than using general area measurements of light and temperature in the berthing space, each participant's rack is individually monitored by an external HOBO. The dual sensors were needed because, as seen in the layouts of the berthing spaces, habitability factors in the vicinity of a rack can vary greatly from participant to participant. For example, one rack in a berthing space may have an overhead white light nearby that is constantly on while another rack in the same space may have no light but a ventilation duct aimed in its direction. Using individual external HOBOs allows proper accounting of this variance.

5. Post-study Assessments

At the conclusion of the study, all instruments were collected and participants completed a series of post-study questionnaires. Participants filled out a post-study POMS (Appendix C). The results were compared with the participant's pre-study POMS results to assess whether a participant's mood and sense of well-being changed over the course of the study. Three additional tests, the Epworth Sleepiness Scale (ESS), Insomnia Severity Index (ISI), and Pittsburgh Sleep Quality Index (PSQI) standardized scales were included in the post-study questionnaire (Appendix D). The ESS assesses an individual's daytime sleepiness through questions where an individual is asked about their propensity to fall asleep in a given situation (Johns, 1991). The results determined the extent to which a participant experienced daytime sleepiness. The presence and severity of clinically significant insomnia is determined via the ISI (Gagnon, Bélanger, Ivers, & Morin, 2013). The PSQI uses short answer and multiple choice to assess an individual's sleep quality (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

E. ANALYTICAL ASSESSMENT

This study provided the opportunity to add to the body of knowledge concerning sleep and Sailors, as well as create entirely new data pertaining specifically to rack curtains. All participants in this study wore an Actiwatch which recorded their activity and sleep. The data from these Actiwatches were downloaded and individually parsed, or scrubbed, to ensure that the final data accurately reflects the participants' periods of activity and sleep. This process also involved using the participant's Activity Log to correctly identify these periods.

At the conclusion of this scrubbing process, adequate sleep data were available on 58 participants out of a total 71 participants in the study. The sleep data was analyzed to determine if it came from a normal distribution. The Shapiro-Wilk Test of Normality was performed and confirmed that the sleep data was normally distributed. This allowed for one-way analysis of variance (ANOVA) of the sleep data.

Within each sleep period, the high and low temperatures for internal and external were identified. The high and low temperatures represented the change in the participant's internal rack temperature during the course of the sleep period. The recorded high and low temperatures were then analyzed for differences. Specifically, four temperature differences were considered during each sleep period:

1. Δ High Temperature = External High Temperature – Internal High Temperature

2. Δ External Temperature = External High Temperature – External Low Temperature

3. Δ Internal Temperature = Internal High Temperature – Internal Low Temperature

4. Δ Total = Δ External Temperature - Δ Internal Temperature

Temperature difference (1) indicated the difference between internal and external high temperatures experienced during a participant's sleep period. Higher temperatures are generally not conducive to promoting sleep.

Temperature difference (2) gave an indication of general area temperature differences. Temperatures were recorded in a total of five berthing compartments, but temperatures could vary greatly within a single berthing compartment due to layout and proximity to habitability factors such as vents, chiller units, doors, and electrical equipment. For this reason, each participant had an individual external temperature measuring device to account for the specific habitability factors within the vicinity of their rack, as opposed to using one general external temperature measurement for the entire berthing space.

Temperature difference (3) gave an indication of temperature difference within the participant's rack during their sleep period. This range of temperatures is what the participant's body experienced, and research has shown that large temperature fluctuations can be disruptive and do not promote good sleep.

Temperature difference (4) compared the change in internal temperature versus the change in external temperature. We theorized that the rack curtain should mitigate large fluctuations in external temperature which would be seen by a larger value for temperature difference (4). This temperature difference, along with temperature difference (3) formed the basis for determining the temperature properties of a rack curtain in promoting sleep.

Light levels were collected internal and external to each participant's rack. Light intensity levels within a berthing space can vary greatly from location to location, due to a rack's location or proximity to a light source. To account for this variance, the internal light measuring device was placed within the rack in a location that was analogous to the participant's eye level and the external device was placed immediately outside the rack. The light data, in lumens per square foot, was recorded every five minutes.

The internal and external light data were filtered to exclude measurements where internal light intensity was greater than external light intensity. Such a situation occurred when the internal rack light was on or the participant was in their rack using a light-emitting device such as a tablet or cell phone. The light data now only looked at where a difference in light intensity occurred. This reduction in light intensity from external to internal was due to the light blocking characteristic of the rack curtain.

III. RESULTS

A. SLEEP RESULTS

On average, participants received 5.78 ± 0.96 hours of sleep out of 6.86 ±1.08 hours of time in bed. The average daily sleep onboard the USS MOMSEN (DDG 92) is shown in Table 2 with the values obtained during other similar studies conducted by NPS.

Table 2. Results of similar sleep studies performed by NPS. Adapted from Miller et al. (2012).

Naval Vessel	Participants	Method of Collecting Sleep Data	Daily Sleep Duration in Hours (M ± SD)
USS MOMSEN (DDG) Mittleider (2018)	71	Actigraphy and sleep logs (n = 58)	5.78 ± 0.96
USS STENNIS (CVN) Nguyen (2002)	33	Actigraphy and sleep logs (n = 28)	6.28 (SD NA)
USS HENRY M. JACKSON (SSBN) Osborne (2004)	41	Actigraphy and sleep logs (n = 29)	6.67 ± 2.56
USS SWIFT (HSV) McCauley, Matsangas, and Miller (2004)	19	Actigraphy and sleep logs	7.5 ± 2.13
USS SWIFT (HSV) Archibald (2005)	21	Actigraphy and sleep logs (n = 21)	6.78 + 1.5
USS CHUNG HOON (DDG) Haynes (2007)	25	Actigraphy (n=22) and sleep logs (n = 25)	7.27 ± 1.03
USS LAKE ERIE and USS PORT ROYAL (CG) (Mason, 2009) and (N. L. Miller & Matsangas, 2009)	70	Actigraphy and sleep logs (n = 70)	5.58 ± 1.92
USS RENTZ (FFG) Green (2009)	24	Actigraphy and sleep logs (n = 24)	6.71 (SD NA)

The sleep data were broken down further by officer and enlisted populations in Table 3 and then again by enlisted rank in Table 4. When broken down by enlisted rank, greater range in average daily sleep duration among ranks can be seen.

Table 3. Officer and Enlisted daily sleep duration and time in bed

Population	Daily Sleep Duration in Hours (M ± SD)	Time in Bed in Hours M ± SD)
Officer (n = 10)	5.5 ± 1.09	6.72 ± 1.13
Enlisted (n = 48)	5.84 ± 0.93	6.92 ± 1.06

Table 4. Daily sleep duration and time in bed by enlisted rank

Rank	Daily Sleep Duration in Hours (M ± SD)	Daily Time in Bed in Hours (M ± SD)
E2 (n = 4)	5.55 ± 0.68	6.95 ± 1.12
E3 (n = 5)	5.26 ± 0.93	6.27 ± 1.37
E4 (n = 13)	5.65 ± 0.69	6.57 ± 0.82
E5 (n = 18)	6.33 ± 0.87	7.44 ± 0.77
E6 (n = 5)	5.07 ± 1.03	6.12 ± 1.35

This study emphasized the potential role of the rack curtain on sleep, specifically assessing if there was a difference in sleep received by enlisted participants with a standard Navy issue rack curtain versus those Sailors using an enhanced commercial rack curtain. Onboard the USS MOMSEN, the standard rack curtain variant is prevalent. For the sleep study, 28 participants had the standard variant and 15 had the enhanced variant. The results for sleep times are shown in Table 5.

Table 5. Daily sleep duration and time in bed by rack curtain variant

Rack Curtain Variant	Average Daily Sleep in Hours (M ± SD)	Average Time in Bed in Hours (M ± SD)
Standard (n = 28)	5.76 ± 0.90	6.78 ± 1.09
Enhanced (n = 15)	5.97 ± 0.80	7.11 ± 0.76

The sleep data are separated by rack curtain variant into two sample groups: standard and enhanced. The data from both these groups are approximately normally distributed, as evidenced by Shapiro-Wilk Tests of Normality. The two samples did not differ in terms of variance (F-test for equality of variance, $F_{1,41} = 1.28$, $p=0.326$). On average, participants with the enhanced curtain received 13 minutes of additional sleep, although this difference was not statistically significant (ANOVA, $F_{1,41} = 0.573$, $p = 0.454$).

B. SURVEY RESULTS

Participants were asked if they consume a caffeinated beverage at least once daily and 89% responded that they did. Thirty-five percent of Sailors responded that they use at least one nicotine product daily and 61% reported that they exercised at least once weekly. At the conclusion of the study, all participants completed the post-study questionnaire. From this questionnaire, participants were asked to evaluate the sleep they received during the study. Nearly two-thirds (64.3%) of participants responded that they received less or much less sleep than they needed. Over half (51.5%) of the participants said their rack curtain improved the temperature within their rack, 36.7% responded that their rack curtain blocked light, and 60% of participants responded that background lighting interfered with their sleep. Over two-thirds (67.14%) of participants felt that temperature (too hot or too cold) interfered with their sleep.

The post-study questionnaire also included the ISI and ESS. Table 6 shows scores among participants who completed the ISI by rack curtain variant. None of the participants with an enhanced rack curtain reported experiencing anything more than sub-threshold insomnia. Wilcoxon’s two-sample rank sum test was used to determine if a difference existed between scores for standard and enhanced variant rack curtain participants. This test did not indicate a significant difference between the two groups ($W=306$, $p=0.670149$).

Table 6. Results of the ISI by rack curtain variant

	Standard	Enhanced
Severe clinical insomnia	1	0
Moderate clinical insomnia	10	0
Sub-threshold insomnia	11	12

The PSQI was also administered to participants during the post-study questionnaire. The majority of participants failed to complete all the answers on the PSQI, making scoring difficult. For this reason, the results of the PSQI were omitted from this thesis.

POMS surveys were administered at the beginning and again at the end of the study to gauge changes in participants' mood over the course of the study. The six factors measured by POMS are tension/anxiety, depression/dejection, anger/hostility, vigor/activity, fatigue, and confusion/bewilderment. These six factors are then used to calculate the participant's Total Mood Disturbance (TMD) score. If a participant's score for a particular factor is greater than the 50th percentile for that factor, they are evaluated as displaying that factor. Figure 11 shows the POMS results among all participants.

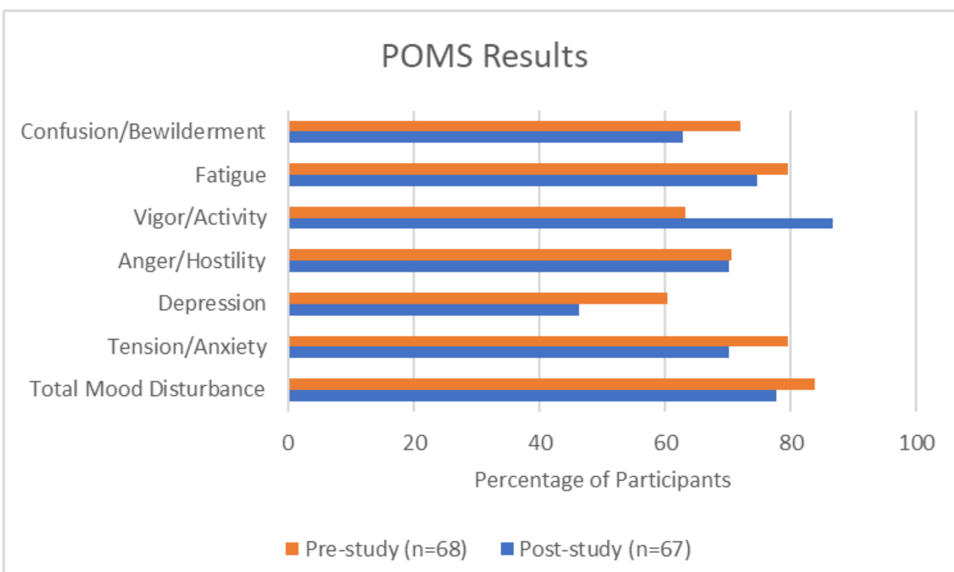

Figure 11. POM results

All factors showed improvement between pre- and post-study surveys. Vigor/ activity, in particular, increase from 63.25% to 86.57% of all participants displaying that factor. All factors with the exception of Depression were determined to be significant via two-sided chi-square test. Figure 12 shows POMS results only amongst those participants with standard or enhanced variant rack curtains.

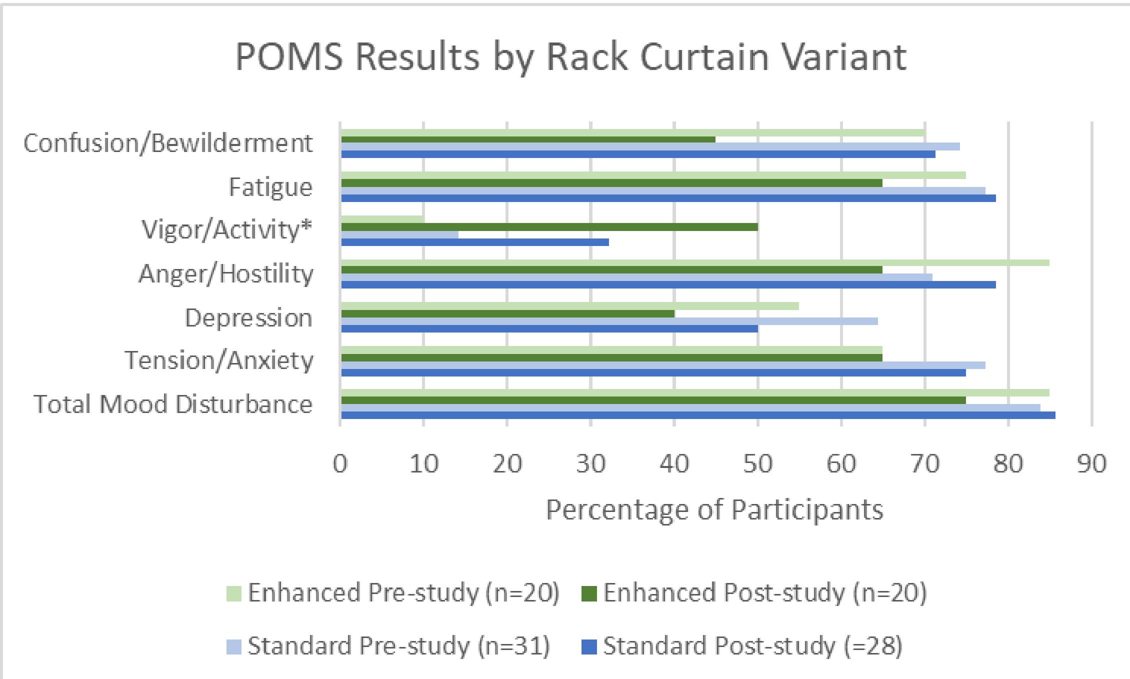

Figure 12. POMS results amongst participants with standard or enhanced variant rack curtains

Amongst enhanced variant rack curtain participants there was improvement in all mood factors except Tension/Anxiety, which remained the same. However, due to the low sample size (n = 20), the only factor showing significance from pre- to post-study was Total Mood Disturbance. Table 7 shows two-sided chi-square test results for pre-study and post-study POMS results among enhanced variant rack curtain participants. Standard variant rack curtain participants saw improvements in all factors except Fatigue and Total Mood Disturbance. All factors with the exception of Depression are significant amongst standard variant rack curtain participants via two-sided chi-square tests. The Wilcoxon 2-

sample rank sum test was performed to determine if Total Mood Disturbance was different in participants with enhanced variant compared to participants with standard variant rack curtains. The test indicated that there was no statistically significant difference in Total Mood Disturbance amongst standard and enhanced rack curtain variants (W=356, p=0.111939).

Table 7. Significance of enhanced rack curtain variant POMS results

	% displaying characteristic pre-study	% displaying characteristic post-study	p-value pre-study	p-value post-study
Total Mood Disturbance	85	75	<0.001	0.0222
Tension/Anxiety	65	65	0.1764	0.1764
Depression	55	40	0.6545	0.3695
Anger/Hostility	85	65	<0.001	0.1764
Vigor/Activity	50	10	1	<0.001
Fatigue	75	65	0.0222	0.1764
Confusion/Bewilderment	70	45	0.0696	0.6545

C. TEMPERATURE RESULTS

Two sets of temperatures were recorded for each participant: one temperature within their rack, and one temperature immediately outside their rack. The two recordings provided temperatures internal and external to the rack curtain when the participant was asleep. Each participant's sleep data were analyzed and at least five distinct sleep periods were identified. These sleep periods were then located within the internal and external temperature data. Figure 13 shows an example of internal (orange dots) and external (blue dots) temperature data for one participant over the course of the study.

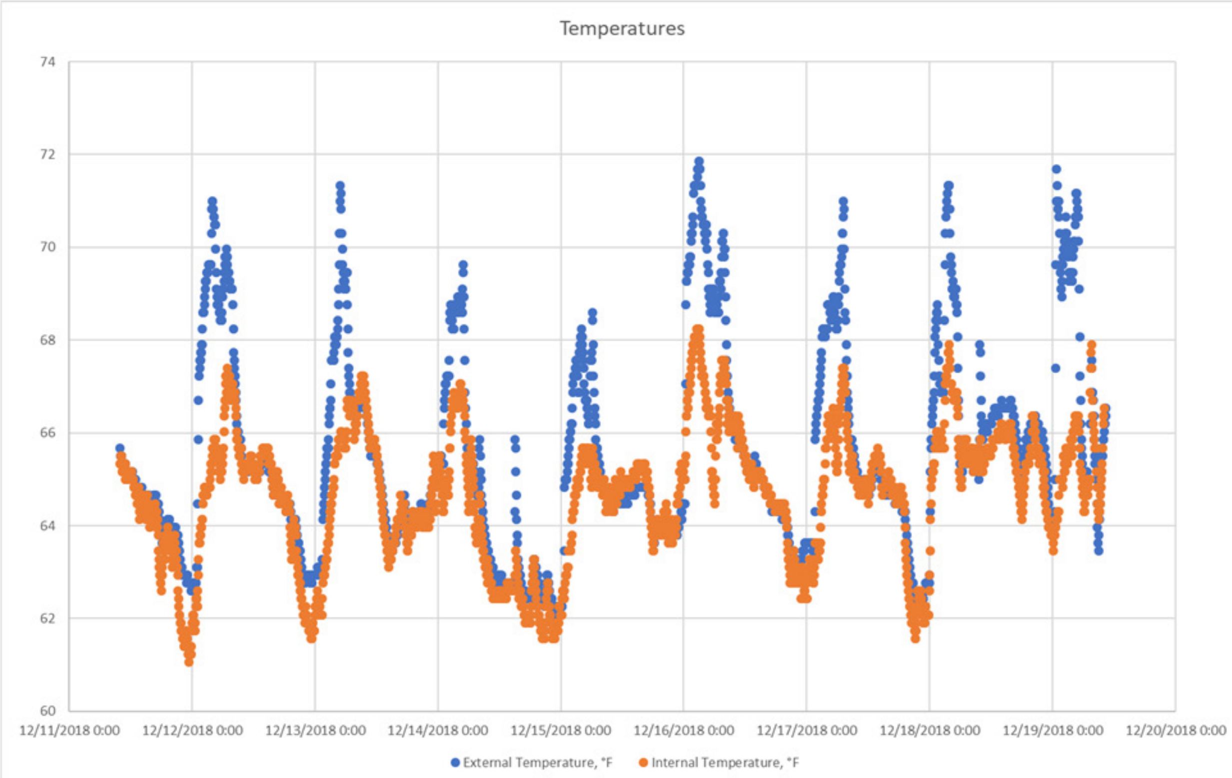

Figure 13. Plot showing external rack temperature overlaid with internal rack temperature

A total of 35 complete sets of temperature and sleep data from all five berthing compartments were analyzed. The temperature data were normally distributed. The average high external temperature was 73.12 (±2.76) °F. The average low external temperature was 66.14 (±1.81) °F. The average difference in external temperatures was 7.0 (±1.83) °F. Amongst all participants, the average internal low temperature was 64.69 (±2.20) °F. The average internal high temperature was 68.76 (±2.23) °F.

The temperature data were then broken down by rack curtain variant. Generally, enhanced curtain internal temperatures were lower, as shown in Table 8. External temperatures for standard rack curtains ranged over 7.35 ± 1.98 °F. For enhanced rack curtains, the external temperatures ranged over 6.5 ± 1.53 °F. The internal temperature differences between standard and enhanced rack curtain variants were 3.97 ± 1.1 °F and 4.21 ± 1.18 °F, respectively. The difference in temperature range between external and internal was greatest among standard rack curtains. The enhanced curtains had lower

overall internal rack temperatures and less temperature fluctuation between external and internal temperatures. Temperature fluctuation between external and internal temperatures was 2.4 ± 0.96 °F for enhanced curtains as opposed to 3.38 ± 1.53 °F for standard curtains.

Table 8. Internal temperatures in °F by rack curtain variant

Rack Curtain Variant	High Average (M ± SD)	Low Average (M ± SD)
Standard (n = 20)	69.3 ± 1.98	65.4 ± 1.41
Enhanced (n = 15)	67.9 ± 2.37	63.7 ± 2.76

Finally, the temperature data were analyzed between the standard and enhanced variant groups. The temperature analysis looked at the difference in range of external temperatures versus range of internal temperatures. A lower value indicated less fluctuation between external and internal temperature ranges. Figure 14 shows the temperature differences between the curtain variants with the enhanced variant rack curtain showing less fluctuation between internal and external temperature ranges.

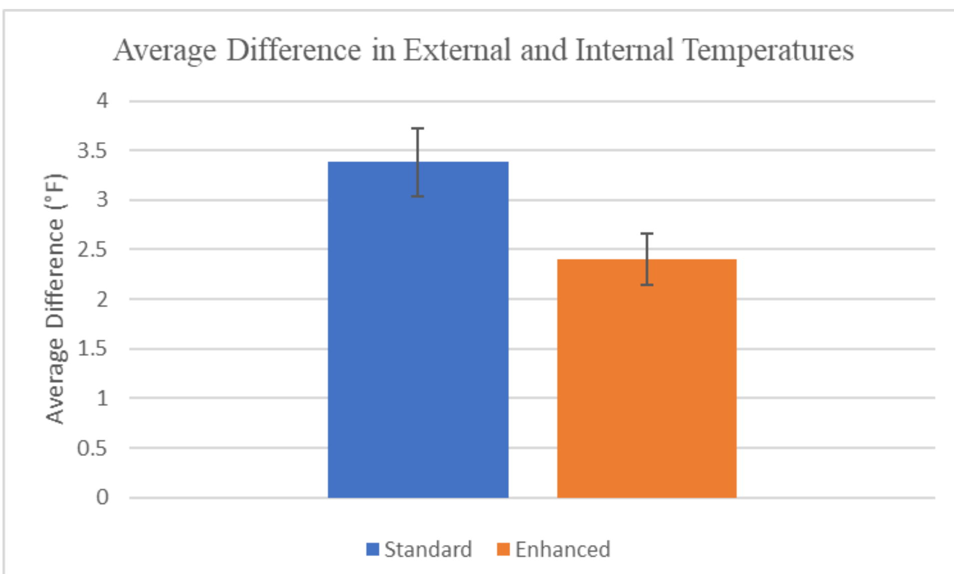

Figure 14. Differences in external and internal temperatures between rack curtain variants

One-way ANOVA of this temperature data returned a p-value of 0.042 which was less than $\alpha=0.05$. The null hypothesis was rejected, and it can be concluded that a difference exists between rack curtain variants and their ability to attenuate temperature changes.

D. LIGHT RESULTS

A total of 23 complete sets of light data were obtained. For all light data, the median total light intensity reduction from external to internal was 44.4% (IQR 27.9-55). The median external light intensity level was 8.43 lm/ft^2 (IQR 5.98-10.65). The median internal light intensity was 3.06 lm/ft^2 (IQR 2.53-3.89). Of the 23 complete sets of light data, 15 were from participants with the standard variant rack curtain and 8 were from the enhanced variant rack curtain. Table 9 summarizes the light data results by rack curtain variant.

Table 9. Light data results by rack curtain variant

Rack Curtain Variant	Median light intensity reduction (%)	Median external light intensity (lm/ft^2)	Median internal light intensity (lm/ft^2)
Standard (n = 15)	42.5 (IQR 27.9-50.1)	8.81 (IQR 8.28-11.17)	3.32 (IQR 2.53-4.75)
Enhanced (n = 8)	51.6 (IQR 29.9-60.4)	6.45 (IQR 5.89-7.61)	2.93 (IQR 1.94-3.69)

Next, the light data were analyzed between the standard and enhanced variant groups. This analysis compared the percent light reduction of external to internal light intensity. The light data for both groups were verified as normally distributed via Shapiro-Wilks Tests of Normality and equal variance was confirmed via F-test. ANOVA of the light data for the two groups resulted in a p-value of 0.41 which was greater than α=0.05, therefore no difference was noted in reduction of light intensity between standard and enhanced variant rack curtains.

IV. DISCUSSION AND CONCLUSIONS

A. SLEEP

The sleep data collected during this study confirms Miller, Matsangas, and Kenney's (2012) findings that Sailors are sleep deprived. The average Sailor in this study obtained 5.78 hours average daily sleep time. That average sleep time certainly does not rank as the lowest seen in similar studies but is likely due to the high-tempo operations that the ship was involved in during the study. These operations took place at all hours and demanded a high level of skill and involvement by the crew. By now the negative effects of sleep deprivation are well known, so every effort should be made to assist Sailors in obtaining adequate sleep.

It is worth noting that the ship in this study utilized a circadian-based watch schedule, so while the length of sleep may not be adequate, the overall quality of the sleep may be better. Sailors in this study had the benefit of a circadian-based watch schedule to assist in optimizing what sleep they could get. Circadian-based watchbills are superior to non-circadian-based watch schedules for reducing daytime sleepiness and improving mood and performance. Brown, Matsangas, and Shattuck (2015) proved this in their study aboard the USS NIMITZ (CVN 68). The usage of circadian-based watchbills is spreading throughout the fleet but it is not yet universal.

B. HABITABILITY

The data collected during this study provided an opportunity to look closely at habitability factors within the berthing spaces. The study found that a participant's rack location within a berthing space can have a large impact on habitability factors affecting them, specifically concerning light and temperature. Something as benign as having a lower rack versus an upper rack in the exact same location can show marked differences in light and temperature.

Per NAVSEA's Shipboard Habitability Design Criteria (NAVSEA, 2016), the design temperature range for occupied spaces is 65°F to 78°F. For this study, the average high temperature and low temperatures during sleep periods in all berthing spaces were

73.13°F and 66.14°F respectively. While that temperature range does fall within the design temperature range, it should be noted that the design criteria is specific to occupied spaces, which are merely defined as compartments that are occupied by crew members for at least 20 minutes (NAVSEA, 2016). There is no design temperature range specifically for berthing spaces, nor is there any mention of promoting sleep in the basis for the design temperature range.

Design compartment illumination levels are provided specifically for berthing spaces and differ from general compartment illumination levels. Lighting within berthing spaces should average 7 lumens whereas general compartments are illuminated to 14 lumens (NAVSEA, 2016). In this study, the average light intensity within the berthing spaces was 8.66 lumens. In keeping with Naval tradition, lights were turned out throughout the ship from sunset throughout the night until dawn. This reduction is beneficial to Sailors with conventional day-based watch schedules, as the darkening of the ship coincides with their scheduled sleep time. However, some Sailors' watch schedules have them sleeping during the day; therefore, they run the risk of having their sleep interrupted by high light levels. In particular, the study noted that Sailors with an upper rack were more exposed to light as the entire top of their rack is open to the berthing space.

C. RACK CURTAIN VARIANTS

The primary emphasis of this study was to look at improving habitability by selection of a rack curtain variant. The study compared the standard issue Navy rack curtain versus a commercially available enhanced rack curtain. In particular, the study was interested in determining which variant was more helpful in creating ideal sleeping conditions: dark and preferably cool.

An early surprise in the study came from the results of the ISI survey which used participants' responses to determine the extent of their insomnia, if any. Half of all participants with standard rack curtains were judged to have moderate or severe clinical insomnia. In contrast, no participants with enhanced rack curtains were judged to have moderate or severe clinical insomnia. It is possible that those results were due to small samples sizes and factors outside the scope of this study.

Participants with enhanced variant rack curtains received, on average, 13 more minutes of sleep than participants with standard variant rack curtains. This increase is not large, but the overall goal of increasing sleep does not benefit from having a lower bound on what constitutes improvement. ANOVA analysis of the two groups did not return a statistically significant difference in average sleep times due to rack curtain variant.

As shown in Figure 13, the internal temperatures closely corresponded to the external, or general area, temperatures. This finding indicates that the rack curtain is open, which allows internal temperature to equalize with external temperature. When sleeping, the rack curtain is customarily shut and internal temperatures begin to differ from external temperatures. In general, the internal rack temperatures were cooler than external rack temperatures. This difference may be due in part to the operations of individual rack fans, which are located at the foot of each rack. The individual rack fans were not specifically investigated as part of this study.

On average, participants with enhanced variant rack curtains had lower internal rack temperatures, although it should be noted that they also experienced lower external temperatures than participants with standard variant rack curtains. According to Wyatt et al. (1999), higher temperatures can disrupt sleep. The average high temperature within standard variant racks was 69.34°F. The average high temperature within enhanced variant racks was lower at 67.93°F. The study compared the range of external temperatures with the range of internal temperatures. Larger fluctuations are undesirable because they can disrupt sleep. One-way ANOVA analysis indicated that rack curtain variant has a significant effect on those fluctuations, with the enhanced variant rack curtain showing the least fluctuation between internal and external temperature ranges.

The enhanced variant rack curtain is constructed from sturdier material than the standard variant rack curtain, and this was apparent in the amount of light reduction. The enhanced variant reduced external to internal light intensity by 46.6% while the standard variant reduction was 41%. The average light intensity within enhanced variant racks was 3 lumens. The standard variant rack curtain is slightly more light-permeable with average internal light intensity at 3.6 lumens. As shown in the work by Figueiro and Rea (2012),

even very low levels of light exposure can disrupt the melatonin and sleep cycles; therefore, it is crucial to minimize light levels as much as possible during sleep.

D. STUDY LIMITATIONS

The analyses for this study would be improved with larger sample sizes for participants with standard or enhanced rack curtain variants. The resulting sample sizes obtained for this study were small and unequal. In order to achieve greater power and effect size, larger samples are required for both groups. Due to the voluntary nature of participation, it was not possible to guarantee an equal number of participants with standard and enhanced rack curtain variants. This resulted in the enhanced rack curtain variant ($n = 15$) being underrepresented versus the standard rack curtain variant ($n = 28$).

This study collected a large amount of data per participant. Ideally, each participant would have pre-survey data, sleep data, light data, temperature data, post-study data, and a completed Activity Log. When this ideal condition was not the case, that participant was not able to be included in some analyses, further compounding the issue of small sample size. The post-study questionnaire contained several smaller standardized survey instruments. The results of one of these, the PSQI, was unusable because the majority of participants failed to respond completely and/or correctly. Another instrument, the POMS, was administered at the start and conclusion of the study to determine if there was any difference in mood changes between standard and enhanced rack curtain variant. The end of the study coincided with the ship's return to its homeport and may have had a confounding effect on post-study POMS results, which saw general improvement among most factors between both groups.

V. RECOMMENDATIONS AND FURTHER WORK

The humble rack curtain is an overlooked piece of equipment that serves as the thin barrier between a Sailor's only personal space and the rest of the ship. Within this personal space, the Sailor obtains his/her all-important sleep, so it is necessary that the rack curtain is selected to aid in this effort. This study found that an enhanced commercially available rack curtain variant can improve temperature regulation within an individual's rack, thereby providing conditions that would minimize sleep disruptions. The enhanced variant rack curtain is also slightly better at excluding light than the standard issue Navy rack curtain.

The enhanced rack curtain can improve habitability within the berthing compartments, not only through its light and temperature properties, but also through the utility of customizations such as pockets or fasteners that are available. This feature can provide Sailors with increased storage and convenience, improving morale and creating tidier spaces. The enhanced variant rack curtain is available in a number of colors and fabrics that are fire retardant and anti-microbial. It is time for the Navy rack curtain to go beyond the initial design criteria of merely providing privacy. This study recommends that the Navy further investigate the usage of enhanced rack curtains as a cost-effective and easily implemented means of improving habitability onboard ships.

The next likely study to continue this work is to outfit all enlisted berthing spaces on a Navy ship with enhanced variant rack curtains. This study would entail recording sleep, mood, and habitability data prior to and after outfitting enhanced variant rack curtains throughout the ship. This study would provide a much larger sample size that allows greater analysis of the effects of enhanced variant rack curtains. There are several varieties of enhanced commercially available rack curtains, so a study to compare them could be performed *in situ* or in a lab, with specific emphasis placed on material analysis and construction. Cost analysis can also be performed and ships can be polled to determine the current ratio of standard to enhanced variant rack curtains in use throughout the fleet currently.

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APPENDIX A. IRB CONSENT FORM

Naval Postgraduate School - Consent to Participate in Research

NPS IRB	
Approved:	12/04/2018
Expires:	12/03/2019

Introduction. You are invited to participate in a research study entitled ***Improving US Navy Shipboard Habitability and Safety: Optimizing Berthing Compartments and Watchstanding Schedules.*** The purpose of this study to assess the impact of different watchstanding schedules, berthing compartment equipment, and berthing compartment conditions on sleep patterns, fatigue, and mood of Navy personnel.

Procedures. This study will take place during an underway period and data collection will last approximately 15-20 days. At the beginning of the data collection period you will be asked to complete the Pre-study Questionnaire, which will include questions about your service and health history, sleeping environment, and mood (approximately 10 minutes to complete). During the underway period, you will wear an actigraph, a device to assess your sleep, and complete an activity log to list your activities (sleep and work) during the day (~10 minutes to complete). Also, throughout the underway period, environmental sensors to measure light, temperature, sound, and odors will be placed throughout the berthing compartments, including inside individual bunk spaces. At the end of the underway period you will complete the Post-study Questionnaire, which will include questions about your watchstanding schedule, sleep environment, sleep quality, sleep history, fatigue levels, and mood (~15 minutes to complete). No Personal Identification Information (PII) will be stored with the data.

Location. The study will take place shipboard during underway periods.

Cost. There is no cost to participate in this research study.

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate, you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. The alternative to participating in the research is to choose not participate in the research.

Potential Risks and Discomforts. The potential risks of participating in this study are minimal; however, please be aware of the following risks:

Privacy risks. There is a minor risk of breach of privacy and confidentiality. All personal identifiable information will be concealed once the data has been collected, and data will be identified using a study ID number. All data will be presented based on group analysis and no individual will be singled out. Raw data will not be disclosed to anyone outside the research team.

Actigraph risks. There is a small risk of skin sensitivity or irritation. The actigraph is designed for prolonged, continuous wear and is considered a low-risk medical device, however, skin irritation may develop. To reduce this risk, the actigraph should not be worn too tightly and the skin under the device should be kept clean and dry. If skin irritation does develop, stop wearing the watch and contact research personnel as soon as possible.

Environmental sensor risks. The environmental sensors do not pose any risks, but their presence in personal spaces may cause emotional discomfort. These sensors will be placed in the berthing compartments and are able to log numerical data but are not capable of recording audio or video and they do not pose a privacy risk. However, if you do not wish to have a sensor in your personal bunk, please inform research personnel.

Anticipated Benefits. There is no direct benefit to you for participating in this research. The results of this research may lead to improvements in the working environment and welfare of the individuals involved as well as other members of the Navy Surface Warfare community.

Compensation for Participation. No tangible compensation will be given.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. All data from this study will be kept on a secure server and/or in a locked facility. Only the researchers will have access to the data.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study please contact the Principal Investigator, Dr. Nita Lewis Shattuck, 831-656-2281, nlshattu@nps.edu. Questions about your rights as a research subject or any other concerns may be addressed to NPS IRB Vice Chair, Dr. Bryan Hudgens, bryan.hudgens@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in the sleep and fatigue study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

____________________________ ____________

Participant's Signature Date

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APPENDIX B. PRE-STUDY QUESTIONNAIRE

Naval Postgraduate School

Date: ____________ Participant ID: ____________

Pre-Study Questionnaire

Instructions: *Please answer ALL questions as accurately as possible. ALL information is confidential and will be used only for research purposes.*

1. What is your age: ____________ years
2. Gender ☐ Male ☐ Female
3. What is your current rate: (for example, FC, HT, OS, IT, GSE) ____________
4. What is your current rank: (for example, E4, O2) ____________
5. What is your Department: ____________
6. Years on active duty: ____________
7. How many times have you been deployed: ____________
8. Total number of months deployed: ____________
9. Describe your current watch schedule: ____________
10. What other watch schedules have you experienced: ____________
11. In which compartment is your bunk located? ____________
12. What is your rack number? ____________
13. In which bunk do you usually sleep? ☐ Upper ☐ Middle ☐ Lower
14. How many of the following caffeinated beverages do you drink <u>on average</u> each day? (Check ALL that apply ☑) and indicate daily amount)
    - ☐ Tea Servings/Cups per day: _______
    - ☐ Coffee Servings/Cups per day: _______
    - ☐ Soda/pop/soft drinks Servings/Cans per day: _______
    - ☐ Energy drinks Servings/Cans per day: _______
    - ☐ Other (specify): ____________ How often: _______ (Example: 4 times per day)
15. Do you use nicotine or tobacco products? (Check one ☑) ☐ Yes ☐ No

    If yes, which of the following nicotine or tobacco products do you use? (Check ALL that apply ☑) and indicate how often)
    - ☐ Cigarettes (If YES, how often? ____________)
    - ☐ Chewing tobacco/snuff (If YES, how often? ____________)
    - ☐ Nicorette gum or patches (If YES, how often? ____________)
    - ☐ Electronic smoke (If YES, how often? ____________)
    - ☐ Other (specify): ____________ (How often? ____________)

1

16. Do you take any prescribed or over-the-counter medications? (Check one ☑) ☐ Yes ☐ No

If YES, please list all medications you take: ______________________________

____

17. Have you ever been diagnosed by a physician with any of the following? (Check ALL that apply ☑)

☐ Insomnia ☐ Obstructive Sleep Apnia (OSA)

18. Do you have an exercise routine? (Check one ☑) ☐ Yes ☐ No

If YES, frequency: ____Times per week (for example, 3 times per week)

What kind of exercise routine do you do? (for example, cardio, weight lifting)

____

How long does this routine take? (for example, 45 minutes) ______________________________

Please complete the POMS.

APPENDIX C. POMS SURVEY

POM180

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

Client ID:____________________ **Age:**______ **Gender:** Male Female (Circle one)

Birth Date:____/____/____ (Month Day Year) **Today's Date:**____/____/____ (Month Day Year)

To the Administrator:

Place a checkmark ✔ in one box to specify the time period of interest.

To the Respondent:

Below is a list of words that describe feelings that people have. Please read each word carefully. Then circle the number that best describes

- ☑ how you have been feeling during the PAST WEEK, INCLUDING TODAY.
- ☐ how you feel RIGHT NOW.
- ☐ other: ____________________

If no box is marked, please follow the instructions for the first box.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
1.	Friendly	0	1	2	3	4
2.	Tense	0	1	2	3	4
3.	Angry	0	1	2	3	4
4.	Worn out	0	1	2	3	4
5.	Unhappy	0	1	2	3	4
6.	Clear-headed	0	1	2	3	4
7.	Lively	0	1	2	3	4
8.	Confused	0	1	2	3	4
9.	Sorry for things done	0	1	2	3	4
10.	Shaky	0	1	2	3	4
11.	Listless	0	1	2	3	4
12.	Peeved	0	1	2	3	4
13.	Considerate	0	1	2	3	4
14.	Sad	0	1	2	3	4
15.	Active	0	1	2	3	4
16.	On edge	0	1	2	3	4
17.	Grouchy	0	1	2	3	4
18.	Blue	0	1	2	3	4
19.	Energetic	0	1	2	3	4
20.	Panicky	0	1	2	3	4
21.	Hopeless	0	1	2	3	4
22.	Relaxed	0	1	2	3	4
23.	Unworthy	0	1	2	3	4
24.	Spiteful	0	1	2	3	4
25.	Sympathetic	0	1	2	3	4
26.	Uneasy	0	1	2	3	4
27.	Restless	0	1	2	3	4
28.	Unable to concentrate	0	1	2	3	4
29.	Fatigued	0	1	2	3	4
30.	Helpful	0	1	2	3	4

Please flip over.
Items continue on the back page...

MHS

Printed in Canada.

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

POMS™

	Not at all	A little	Moderately	Quite a bit	Extremely
31. Annoyed	0	1	2	3	4
32. Discouraged	0	1	2	3	4
33. Resentful	0	1	2	3	4
34. Nervous	0	1	2	3	4
35. Lonely	0	1	2	3	4
36. Miserable	0	1	2	3	4
37. Muddled	0	1	2	3	4
38. Cheerful	0	1	2	3	4
39. Bitter	0	1	2	3	4
40. Exhausted	0	1	2	3	4
41. Anxious	0	1	2	3	4
42. Ready to fight	0	1	2	3	4
43. Good natured	0	1	2	3	4
44. Gloomy	0	1	2	3	4
45. Desperate	0	1	2	3	4
46. Sluggish	0	1	2	3	4
47. Rebellious	0	1	2	3	4
48. Helpless	0	1	2	3	4
49. Weary	0	1	2	3	4
50. Bewildered	0	1	2	3	4
51. Alert	0	1	2	3	4
52. Deceived	0	1	2	3	4
53. Furious	0	1	2	3	4
54. Efficient	0	1	2	3	4
55. Trusting	0	1	2	3	4
56. Full of pep	0	1	2	3	4
57. Bad-tempered	0	1	2	3	4
58. Worthless	0	1	2	3	4
59. Forgetful	0	1	2	3	4
60. Carefree	0	1	2	3	4
61. Terrified	0	1	2	3	4
62. Guilty	0	1	2	3	4
63. Vigorous	0	1	2	3	4
64. Uncertain about things	0	1	2	3	4
65. Bushed	0	1	2	3	4

Please ensure you have answered every item.
Thank you for completing this questionnaire.

APPENDIX D. POST-STUDY QUESTIONNAIRE

Naval Postgraduate School

Date: ____________ Participant ID: ____________

Post-Study Questionnaire

Instructions: *This questionnaire refers to your experiences during the last underway period (approximately 17 days). Please answer ALL questions as accurately as possible. ALL information is confidential and will be used only for research purposes.*

1. What was your watchstanding schedule during this past underway? (Check ALL that apply ☑)

☐ 4/8	☐ 6/18
☐ 3/9	☐ 12/12
☐ 5/10	☐ Day 5 / Night 3
☐ 5/15	☐ Day 2 / Night 3
☐ 6/6	☐ Day 6 / Night 2
☐ 6/12	☐ Other: ____________

2. When did you stand watch? (for example, 0000-0400 and 1200-1600) ____________

3. Where did you stand watch? (for example, CIC, Bridge, Roving watch) ____________

4. The sleep that I received during the past underway was: (Check one ☑)

☐ Much less than I needed ☐ Less than I needed ☐ About right ☐ More than I needed ☐ Much more than I needed

5. The sleep that other Sailors received during the past underway was: (Check one ☑)

☐ Much less than they needed ☐ Less than they needed ☐ About right ☐ More than they needed ☐ Much more than they needed

6. How did your workload during this past underway compare to your normal workload while underway? (Check one ☑)

☐ Much less than usual ☐ Less than usual ☐ About usual ☐ More than usual ☐ Much more than usual

7. How did the workload of other Sailors during this past underway compare to their normal workload while underway? (Check one ☑)

☐ Much less than usual ☐ Less than usual ☐ About usual ☐ More than usual ☐ Much more than usual

8. When going to sleep do you do anything to help you get to sleep or to minimize disturbances of your sleep, such as: (Check ☑ one per row)

1. Wear earplugs	☐ Yes	☐ No
2. Wear eyeshades	☐ Yes	☐ No
3. Listen to music	☐ Yes	☐ No
4. Other (specify) ____________	☐ Yes	☐ No

9. Do you look at devices with screens before going to bed? (Check one ☑) ☐ Yes ☐ No

If YES, which of the following devices do you use? (Check ALL that apply ☑) and indicate how often)

☐	TV	(If YES, how often? ____________)
☐	Tablet	(If YES, how often? ____________)
☐	Smartphone	(If YES, how often? ____________)
☐	Computer	(If YES, how often? ____________)
☐	Other (specify): ____________	(How often? ____________)

10. What type of curtains are on your rack? (Check one) ☐ Standard (no pockets) ☐ Enhanced (with pockets)

11. How do you think your rack curtain changes your ability to sleep? (Check one per row)	Disagree		Neutral		Agree
	-2	-1	0	1	2
a) Blocks light (makes the bunk darker)	O	O	O	O	O
b) Temperature (makes the bunk more comfortable)	O	O	O	O	O
c) Ventilation (makes the air better)	O	O	O	O	O
d) Noise (makes the bunk quieter)	O	O	O	O	O
e) Other: ____________	O	O	O	O	O

12. Please rate the following factors and indicate how much they interfere with or promote your sleep in the bunk. (Check one ☑ per row)	Interferes		No effect		Promotes
	-2	-1	0	1	2
a) Quality of sleep surface/mattress	O	O	O	O	O
b) Bunk size	O	O	O	O	O
c) Sheets	O	O	O	O	O
d) Blanket	O	O	O	O	O
e) Pillow	O	O	O	O	O
f) Curtains	O	O	O	O	O
g) Ship motion	O	O	O	O	O
h) Background lighting	O	O	O	O	O
i) Heat	O	O	O	O	O
j) Cold	O	O	O	O	O
k) Ventilation	O	O	O	O	O
l) Low humidity/ dry air	O	O	O	O	O
m) High humidity	O	O	O	O	O
n) Noise from other Sailors in the compartment	O	O	O	O	O
o) Noise inside the compartment (machinery, etc.)	O	O	O	O	O
p) Noise outside the compartment	O	O	O	O	O
q) 1MC	O	O	O	O	O
r) Smell in the room (odors from other people)	O	O	O	O	O
s) Smell in the room (other)	O	O	O	O	O
t) Thoughts running through your head	O	O	O	O	O
u) Readiness for sleep	O	O	O	O	O
v) Trips to the head	O	O	O	O	O
w) Lack of privacy	O	O	O	O	O
x) Not enough time to sleep	O	O	O	O	O
y) Other: ____________	O	O	O	O	O

ESS Instructions: *How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in the last 1 week. Even if you have not done some of these things recently try to work out how they would have affected you.*

Check ☑ the most appropriate number for each situation.	CHANCE OF DOZING None (0)	Slight (1)	Moderate (2)	High (3)
Sitting and reading	☐	☐	☐	☐
Watching TV	☐	☐	☐	☐
Sitting inactive in a public place (e.g. a theater or a meeting)	☐	☐	☐	☐
As a passenger in a car for an hour without a break	☐	☐	☐	☐
Lying down to rest in the afternoon when circumstances permit	☐	☐	☐	☐
Sitting and talking to someone	☐	☐	☐	☐
Sitting quietly after a lunch without alcohol	☐	☐	☐	☐
In a car, while stopped for a few minutes in traffic	☐	☐	☐	☐

ISI Instructions: *Please rate based on the last 1 week.*

Check ☑ the most appropriate for each situation.	None (0)	Mild (1)	Moderate (2)	Severe (3)	Very Severe (4)
Difficulty falling asleep	☐	☐	☐	☐	☐
Difficulty staying asleep	☐	☐	☐	☐	☐
Problems waking up too early	☐	☐	☐	☐	☐
How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?	Very Satisfied ☐	Satisfied ☐	Moderately Satisfied ☐	Dissatisfied ☐	Very Dissatisfied ☐
How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?	Not at all Noticeable ☐	A Little ☐	Somewhat ☐	Much ☐	Very Much Noticeable ☐
How WORRIED/DISTRESSED are you about your current sleep problem?	Not at all Worried ☐	A Little ☐	Somewhat ☐	Much ☐	Very Much Worried ☐
To what extent do you consider your sleep problem to INTERFERE with your daily functioning CURRENTLY? (i.e. daytime fatigue, mood, ability to function at work, concentration, memory, mood, etc.)	Not at all Interfering ☐	A Little ☐	Somewhat ☐	Much ☐	Very Much Interfering ☐

Pittsburgh Sleep Quality Index Instructions: *The following questions relate to your usual sleep habits during the last 1 week only. Your answers should indicate the most accurate reply for the majority of days/nights in the last 1 week. Please answer all questions.*

1.	In the last week, what time have you usually gone to bed at night?	Bed Time: ____________
2.	During the last week, how long (in minutes) has it usually taken you to fall asleep each night	Number of Minutes: ____________
3.	In the last week, what time have you usually gotten up in the morning?	Getting up time: ____________
4.	During the last week, how many hours of actual sleep did you get at night? (this may be different than the number of hours you spent in bed.)	Hours of Sleep per Night: ____________

Instructions: *For each of the remaining questions, check the one best response.*

5. During the last week, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	3 or more times a week
a) Cannot get to sleep within 30 mins	○	○	○	○
b) Wake up in the middle of the night or early morning	○	○	○	○
c) Have to get up to use the bathroom	○	○	○	○
d) Cannot breathe comfortably	○	○	○	○
e) Cough or snore loudly	○	○	○	○
f) Feel too cold	○	○	○	○
g) Feel too hot	○	○	○	○
h) Had bad dreams	○	○	○	○
i) Have pain	○	○	○	○
j) Other reason(s), please describe: ____________ How often during the past month have you had trouble sleeping because of this?	○	○	○	○

6. During the last week, how would you rate your sleep quality overall?	Very Good ○	Fairly Good ○	Fairly Bad ○	Very Bad ○
7. During the last week, how often have you taken medicine to help you sleep (prescribed or "over the counter"?	Not during the past month ○	Less than once a week ○	Once or twice a week ○	Three or more times a week ○
8. During the last week, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	○	○	○	○
9. During the last week, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	Not a problem at all ○	Only a very slight problem ○	Somewhat of a problem ○	A very big problem ○

Please complete the POMS

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